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ABSTRACT

The Program for Research in Teaching and Learning of the National Science Foundation (NSF) supports basic and applied research on what NSF considers to be the most significant factors that underlie effective teaching and learning in science and mathematics at all levels. This document provides descriptions of projects funded during fiscal years 1984-86. Projects include: (1) teaching and learning in specific subject areas (chemistry, physics, mathematics, biology, computer science, etc.); (2) the early development of reasoning and understanding, and the processes by which students learn to solve problems in logic, mathematics, science and technology; (3) the acquisition of knowledge and its representation in specific areas of science and mathematics; (4) factors that influence the quality and effectiveness of instruction in science and mathematics and the participation and achievement of students at various ages; and (5) factors that are influential in the development and maintenance of interest, including early development of motivation and talent in science, mathematics and technology. The types of research projects likely to be funded in fiscal year 1987 are also presented. (TW)

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National Science Foundation

Directorate for Science and Engineering Education

March 1987

SUMMARY OF GRANTS, FY 1984-86

Research in Teaching and Learning Program

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SE 048 358

The Foundation welcomes proposals on behalf of all qualified scientists and engineers, and strongly encourages women and minorities to compete fully in the programs described in this document.

In accordance with Federal statutes and regulations and NSF policies, no person on grounds of race, color, age, sex, national origin, or physical handicap shall be excluded from participation in, denied the benefits of, or be subject to discrimination under any program or activity receiving financial assistance from the National Science Foundation.

Catalog of Federal Domestic Assistance Number 47.067, Materials Development, Research and Informal Science Education.

NSF has TDD (Telephonic Device for the Deaf) capability which enables individuals with hearing impairment to communicate with the Division of Personnel and Management for information relating to NSF programs, employment, or general information. This number is (202) 357-7492.

The Foundation provides awards for research in the sciences and engineering. The awardee is wholly responsible for the conduct of such research and preparation of the results for publication. The Foundation, therefore, does not assume responsibility for such findings or their interpretation.

COVER: RESEARCH TO UNDERSTAND THE DEVELOPMENT OF CHILDREN'S INTEREST IN SCIENCE

NSF 86-84

Research In Teaching and Learning

> "The Nation that dramatically and boldly led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the 21st century."
>
> *Educating Americans for the 21st Century*
> The Report of the NSB Commission,
> September 1983

The NSB Commission Report emphasized that "early and substantial exposure to mathematical and scientific concepts and processes is critical to later achievement" and "essential to truly equal opportunity and continuing study in these fields." The report further urged that this be made a high priority for *all* the Nation's youth. If the Nation is to achieve these goals, we need to know what have been, and what are, the barriers to effective teaching and learning. We need to investigate and understand these barriers at the individual, family, institutional and societal levels. We need to *use* this knowledge in the design of more effective educational programs. The Program for Research in Teaching and Learning is one small instrumentality for creating the knowledge that will assist in this process.

The program supports basic and applied research on the most significant factors that underlie effective teaching and learning at all levels. This includes improved knowledge of how interest and motivation develop in science and mathematics, of how students learn complex concepts in science and mathematics, of how they learn to apply these concepts effectively in real problem solving situations and in making personal decisions, and of the factors that are most influential in governing their participation and performance in school science and mathematics courses.

Scope of the Program in 1985 and 1986

During the past two years the program has included support for research in such areas as:

- teaching and learning in specific subject areas (chemistry, physics, mathematics, biology, computer science, etc.);
- the early development of reasoning and understanding, and the processes by which students learn to solve problems in logic, mathematics, science and technology;
- the acquisition of knowledge and its representation in specific areas of science and mathematics;
- factors that influence the quality and effectiveness of instruction in science and mathematics and the participation and achievement of students at various ages;
- factors that are influential in the development and maintaining of interest, including early development of motivation and talent, in science, mathematics, and technology.

Characteristics of the Program

Several projects funded in 1985 and 1986 focus on understanding the early development of children's problem-solving abilities in mathematics and science and will attempt to understand the influence of pre-established misconceptions on the problem-solving process. Some projects also seek to identify teaching strategies that are effective in developing problem- solving ability and examine teacher cognition, including beliefs about the nature of the subject and the nature of the young learner. An important feature of these projects is the collaboration of subject matter experts (mathematicians and scientists) with researchers from the behavioral and social sciences and education. Many of these research projects include direct linkages to the development of instructional materials for students and teachers and to the design of informal science education programs.

1985 and 1986 Awards

The research program made 22 awards from FY 1985 funds, totalling $3.0 million. The program considered 130 proposals requesting $37.0 million. The original allocation for the research program was $2.0 million; because several of the projects had components significant to other programs in the Division they were jointly funded, bringing the total to $3.0 million.

In 1986, the research program considered 70 proposals and made 16 new awards, totalling $1.9 million; another $0.8 million was devoted to continuing awards, bringing the program's total to $2.7 million.

Representative projects:

- A project at the University of Michigan is investigating individual and situational factors that promote high motivation and achievement in 4th and 5th grade science students.
- The University of Wisconsin seeks to develop a detailed picture of first grade teachers' beliefs and cognitive processes, the relationships of these to instructional behavior, and the resulting effects on children's learning of mathematics. The results will be used as the basis for instructional material for teachers.
- The Johns Hopkins University is conducting a longitudinal study of 7th graders who exhibit exceptional reasoning ability in mathematics. The study will examine the educational, family background and personality characteristics of these students in order to develop better ways to predict and cultivate high achievement in mathematics and science.
- The University of Massachusetts — working through a coalition of university researchers and high school physics

teachers — will investigate instructional strategies that are effective in overcoming difficulties in learning critical concepts of physics.

- A National Academy of Sciences project will examine strategic policies and will design Academy activities intended to increase the involvement of scientists, mathematicians and engineers in research on the learning and teaching in their subject matter areas.

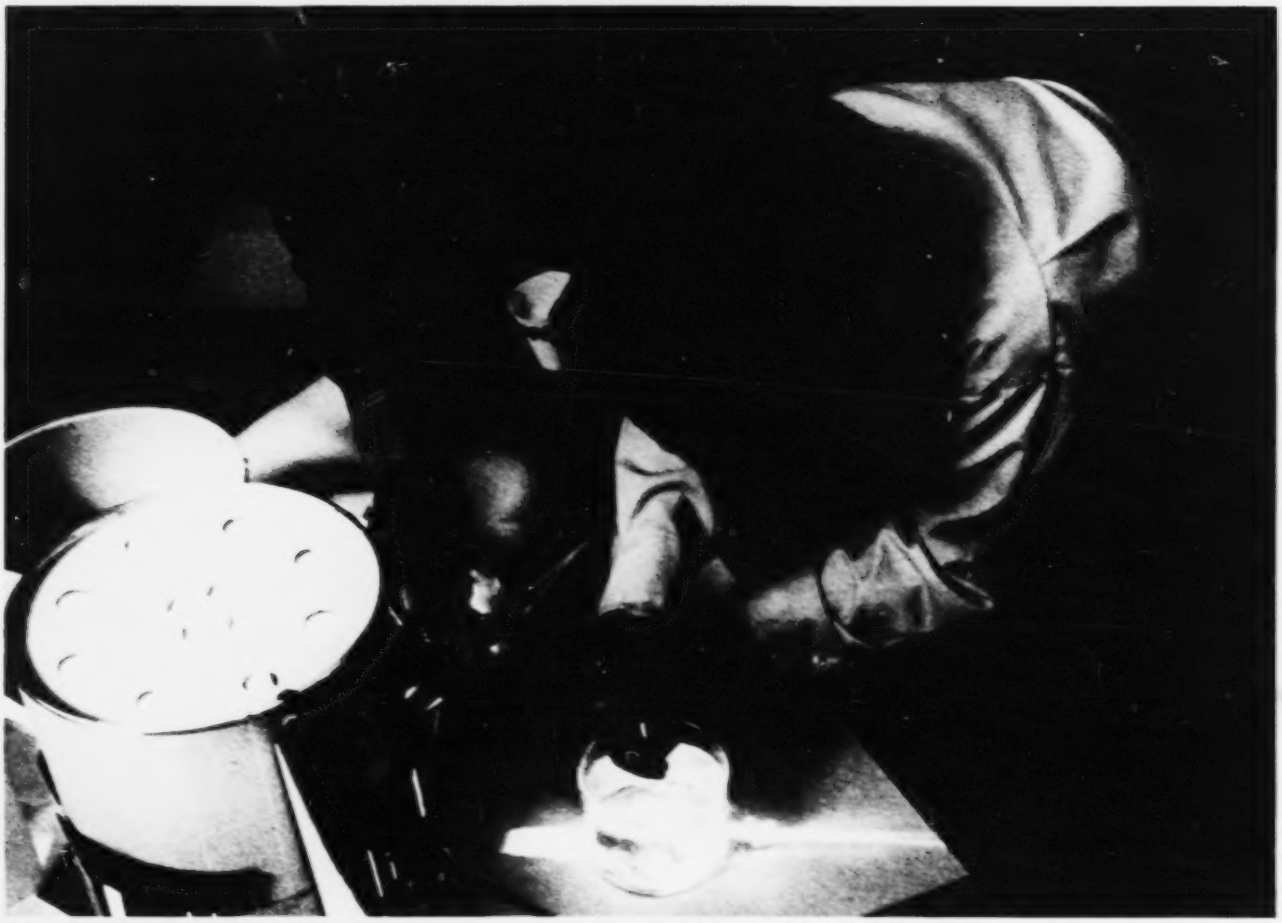
Current Funds and Emphasis

The program plans to award approximately $3.5 million in 1987 for new projects and for sustaining continuing projects.

To have a meaningful impact, these limited resources must be focused on problems of science education that offer the greatest progress and cost-effectiveness. For this reason, the program continually tries to identify the areas of promise and significance.

At this time, for example, we have a particular interest in the relationships between teachers' subject knowledge and competence and their performance in the classroom. Clearly, this relationship has great importance to issues of teacher preparation, classroom materials and the links to in-service training. We believe that this is a case where comparatively modest investment could have major impact on the long-term quality of science education.

Another important area concerns the effects and significance of direct experience in the learning process. Both in and out of school, our experiences set an important cognitive and affective



RESEARCH TO UNDERSTAND THE INFLUENCE OF DOING SCIENCE ACTIVITIES ON YOUNG CHILDREN'S THINKING

background. Yet there is inadequate understanding of how experiences are internalized and incorporated in more traditional learning processes. For example, how does coupling first hand observations with reflective dialogue affect the interest and engagement of teachers and students and what are the effects on cognitive development? The significance of understanding such questions to early hands-on activities in mathematics and science, to later laboratory courses, to research participation, and to issues of participation and performance by women, minorities and the handicapped, could be substantial.

We strongly urge proposers to develop and test staff reactions to a preliminary proposal before undertaking the effort and investment of a formal proposal. More generalized research questions are often more appropriately addressed by the Foundation's behavioral sciences research programs, and it is always advisable to explore potential proposal ideas through discussion or a letter-of-inquiry to the program staff.

Raymond J. Hannapel
Program Director

Susan C. MacAdam
Program Secretary

Research in Teaching and Learning
Program

National Science Foundation
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(202) 357-7071

RESEARCH ON TEACHER KNOWLEDGE AND THE TEACHING OF MATHEMATICS

RESEARCH IN TEACHING AND LEARNING PROGRAM

FY 1984 Awards

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MDR 8318629
FY 84 $109,453 (RTL)
$328,361 (IS)
(36 mos)

"Structures for Plan-based Tutoring: Applications to Geometry"

The purpose of this study is to develop a theory of student problem-solving in a formal domain such as geometry and to develop an automated tutoring system to help students acquire problem-solving skills. The study is designed to test ACT, a general theory of skill acquisition, and to establish a set of guidelines for constructing automated tutoring systems.

An explicit simulation of how students use and refine their knowledge of geometry through problem-solving, specifically theorem proving, will be developed and tested. Protocols will be gathered from high school students doing proofs in an automated theorem-proving environment. Models of students' knowledge will be constructed based on their performance. Changes in these student models will then be used to measure the students' learning. The current development of an intelligent computer-assisted instructional system for tutoring students in geometry theorem-proving will continue. Instructional strategies based on student performance and the learning theory will be tested.

The outcome of this research will be: (a) a better understanding of how skills are acquired and organized; (b) a detailed model of the information processing involved in geometry; (c) a procedure for applying theories of learning to the design of tutorial programs; and (d) a clearer idea of the issues involved in intelligent computer-assisted instruction.

James T. Fey
UNIVERSITY OF MARYLAND
Department of Mathematics
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MDR 8470173
FY 84 $114,296 (AAT)
$342,203 (RTL)
(30 mos)

"Effects of Computer-Based Curricula in School Algebra"

The numeric, symbolic, and graphic information processing capabilities of computers are now widely available as tools for mathematical problem-solving. Thus, it is essential to re-examine the content and organization of traditional school mathematics courses so that they reflect the new realities of what students can and should learn. The proposed research focuses on the impact of computing in algebra and its implications for change in the secondary school curriculum. A series of experimental curriculum modules will be developed, tested in algebra classes, and carefully evaluated to determine feasibility of curricula which use computers as basic tools to: (1) develop students' understanding of algebra concept and their ability to solve problems requiring algebra before they master conventional manipulative skills, (2) make the concept of function a central organizing theme for theory, problem-solving and technique in algebra.

Thomas R. Post
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UNIVERSITY OF MINNESOTAA
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MDR 8470077
FY 84 $718,325
24 mos)

Co-P.Is:

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DeKalb, IL 60115

Richard Lesh
WICAT
Orem, UT 84057

"The Role of Rational Number Concepts in the Development of Proportional Reasoning Skills"

This project will examine the rational number related processes and skills used by junior high students as they develop the ability to reason proportionally. It builds directly upon a productive program of collaborative research involving these investigators begun in 1979 with the Rational Number Project and will continue to develop a theoretical model that addresses representational modes of mathematical concepts. This multi-site project will develop and test both instructional and evaluative materials, some of which will be microcomputer based. These materials will be used as a basis for teacher training and also for a series of large group (experimental) and small group (clinical) investigations.

Specifically, this project will:

1. Identify cognitive and knowledge relationships between rational number understanding and proportional reasoning tasks.

2. Develop instructional and evaluation materials for this investigation, and adapt segments of these materials to the microcomputer.
3. Conduct teacher education sessions about the issues concerning children's proportional reasoning ability and the use of project materials for research information.
4. Conduct teaching experiments with small group and experimental studies with classroom size groups to investigate effects of knowledge of specific identified rational number concepts on children's ability to acquire proportional reasoning ability.

The project addresses an important conceptual area; the attainment of proportional reasoning ability is a critical prerequisite to further study of mathematics, science and engineering and to the basic understanding of scientific phenomena.

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MDR 8470081
FY 84 $820,320

"Applying the Results of Physics Education Research to Teacher Preparation: Development of Instructional Materials and a Model Program"

In order to make scientific concepts meaningful to precollege students, the teacher needs to have a solid grasp of the underlying conceptual structure of physics as well as the reasoning that has led to the building of this structure. Typical courses taken in college physics and engineering departments do not emphasize this qualitative understanding. Involvement of teachers in the development of the new materials is an essential element of the plan.

This project will develop instructional materials for precollege teachers that incorporate findings from research on the learning of science and mathematics. Specific conceptual and reasoning difficulties encountered in the study of physics will be addressed by developing three in-depth modules covering mechanics, electricity and magnetism, and optics. A model teacher education program will also be developed to demonstrate ways in which science departments can help improve the ability of precollege teachers to teach science.

The Physics Education Group in the Department of Physics at the University of Washington has already had considerable experience in developing curricula base on research into student conceptual difficulties. They are widely recognized for their past contributions of very high quality materials for science education.

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MDR 8409199
FY 84 $67,980
(12 mos)
Funded jointly with BNS, Sociology Program

"Precollege Origins of Careers in Science and Engineering"

As the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology stated in a recent report, "far too many emerge from the Nation's elementary and secondary schools with inadequate grounding in mathematics, science and technology." A key to understanding this serious national problem is to discover what influences high school students to choose careers in science and engineering. The choosing of science and mathematics can have a profound effect on subsequent determinants of choosing science and engineering careers by means of a statistical analysis of a large and detailed data base on high schools and high school students.

The High School and Beyond (HS&B) survey is a national longitudinal study of high school sophomores and seniors of 1980, which was sponsored by the National Center for Education Statistics. Approximately 30,000 high school sophomores completed a long questionnaire in 1980 and then a second questionnaire in 1982. At each time a short battery of cognitive tests was given and, after graduation, transcripts of the high school records of one-half the sample members were obtained and added to the HS&B data set. This data set is unusual in its national representativeness and its inclusion of data regarding high schools, teachers, student attitudes, student abilities, and the actual formal record of courses taken and grades received.

The HS&B data will be used to test specific research hypotheses derived from career development literature and from intensive additional interviews to be conducted with a small sample of current high schoolers. In particular, the effect of enrolling in certain subjects and of success or failure in these subjects on changes in career choice from the sophomore to senior year will be tested. The differential effects for males and females and for members of ethnic minority groups will also be examined.

FY 1985 Awards

Camilla P. Benbow
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515/294-1742

MDR 8470387
FY 85 $143,011
(12 months)
FY 86 $166,567

"A Longitudinal Study of the Educational Patterns of High Achievers in the Sciences"

The Johns Hopkins Study of Mathematically Precocious Youth (SMPY) has identified roughly 10,000 preadolescent boys and girls (mostly 7th-graders) who reason exceptionally well mathematically, and have an exceptional potential for high achievement in mathematics and sciences. Since its initiation in 1971, the study has conducted a wide range of tutoring, counseling and other activities that help students to realize this potential.

In the current research, factors associated with becoming high academic achievers by the end of college will be identified. SMPY has extensive questionnaires completed by these students at age 12, when they had just entered college, and (in progress) a year past expected college graduation. The study will document the educational, familial background, and personality characteristics of these mathematically talented students. Variables that predict high academic achievement will be used to construct a quantitative model for achievement in mathematics and sciences, and the effects of the chosen variables on mathematics and science achievement will also be studied. Possible explanations for and consequences of dramatic sex differences that have been observed will also be investigated.

Phyllis C. Blumenfeld
Department of Education
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MDR 8550437
FY 85 $109,622
FY 86 $ 35,339
(12 months)

Co-P.I.:

Judith L. Meece
Department of Education
UNIVERSITY OF NORTH CAROLINA-CHAPEL HILL
Chapel Hill, NC 27514

"Mastery Orientation Toward Learning Science in Elementary Schools"

This study will examine the effects of tasks, teacher behavior and individual characteristics on students' motivation to master cognitively complex science material. The Principal Investigators plan to:

- select 10 well-managed 4th and 5th grade classrooms taught by experienced science teachers,
- identify children with different orientation toward achievement,
- select three science units which require critical thinking, but where the tasks vary in their format and social organization,
- observe and detail teacher and student behavior during these units,
- survey and interview children following observations to explore their perceptions of task demands, expectations for performance, learning strategies, and understanding of the lesson.

The data from student interviews, teacher questionnaires, and classroom observations will be used to characterize the learning orientation of students. The research design will allow a comparison of the reactions of individual students, both within a classroom and to similar tasks across classrooms. In this manner, the investigators plan to identify the individual and situational factors that promote development of a mastery orientation toward science learning.

The results will be disseminated through packaged materials, workshops and conference presentations given at local, regional and national levels.

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Amherst, MA 01003
413/545-0988

MDR 8470579
FY 85 $314,379
(36 months)

"An Investigation of Methods for Overcoming Conceptual Difficulties in Science"

Recent research has identified a large number of misconceptions held by science students (particularly in mechanics), which seriously interfere with their ability to learn more advanced concepts. Many of these misconceptions are present prior to instruction and are exceedingly difficult to change during instruction. For example, many students believe that an inanimate object which supports another object is not exerting an upward force, and many others believe that a projectile thrown upward is driven upward by a force even after it leaves the thrower's hand.

Many of these common misconceptions are so deep-seated that they still persist after a long-term physics course is completed.

Thus, they present an important long-term barrier to understanding. A few innovative teaching attempts have been reported with varying degrees of success, but the inconsistency of the results indicates how little is really understood about the nature of these misconceptions.

This project will conduct an intensive investigation of teaching strategies for several specific high school level physics misconceptions in an attempt to develop a general theory of instruction. The studies will use group testing and individual interviews. Innovative instructional methods will be developed and tested in a large group setting in order to provide a detailed analysis of the effects of these methods.

Building a national coalition of researchers and interested high school physics teachers working together to explore innovative teaching methods for physics is a key feature of the project. The project will result in the definition of one or more general teaching methods for dealing with misconceptions in physics with possible applications to other areas of science and mathematics. This type of research and development project is a fundamental step toward the production of effective new course materials and software for students and teachers.

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MDR 8550236
FY 85 $231,843
(12 months)
FY 86 $299,866
FY 87 $199,951
FY 88 $173,254

Co-P.I.s

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Penelope Peterson
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"Studies of the Application of Cognitive and Instructional Science to Mathematics Instruction"

This project will explore the application of instructional and cognitive science to the effective teaching of higher cognitive mathematics skills.

A series of integrated studies will examine the relationship of teachers' cognitions and beliefs, mathematics instruction in first-grade classrooms, and children's learning of addition and subtraction skills, concepts and word problems. The research methodologies will include individual interviews/semantic analysis of word problems, "thinking aloud" and process-product observational techniques.

Two studies during the first year will provide information on teachers' cognitions and beliefs. Instructional materials for teachers will also be developed during Year I, to increase the teachers' knowledge so that they can create their own curriculum. The teacher materials will include exemplary activities, assessment procedures, classroom organizational plans, etc., that teachers can both critique and use as models.

During the second year, an in-depth instructional study will include formal and informal observations of 15-25 first grade teachers. Students' classroom behavior and teachers' instructional behavior will be observed in order to develop a detailed picture of teachers' beliefs and cognitive processes, the relationships of these to instructional behavior, and the effect of instructional behavior on children's cognitive processes and learning of mathematics.

During Year III, the investigators will evaluate the effect of the curriculum on the children as they progress to second grade, intensively study the more effective teachers from Year II by clinical procedures and revise the teacher education materials. During Year IV, the focus will be on analyses of research results, and on publication and dissemination.

Fred M. Goldberg
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SAN DIEGO STATE UNIVERSITY
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619/265-5157

MDR 8470449
FY 85 $176,700
(28 months)

"Empirical Investigation of Difficulties in Understanding Optics, Kinematics, and Heat and Temperature Among Precollege Teachers"

Often students bring with them into their college physics and physical science courses preestablished beliefs about physical phenomena which are at odds with correct scientific principles. These "alternative conceptions" can contribute great difficulty to students who are struggling to learn physics. This project will investigate such alternative conceptions, held by inservice elementary and middle school teachers and by preservice teachers before formal instruction in their college science courses.

These investigators will then examine some of the difficulties that such preservice teachers have in understanding physics during formal instruction. The research will be carried out in the content areas of optics, kinematics, and heat and temperature. The primary data source will be the "individual demonstration interview," in which the student is asked to make predictions and give explanations for a variety of tasks involving real apparatus. Once information is obtained from the interviews about the nature of specific difficulties, their prevalence will be determined by administering questionnaires to class-size groups. This project will also develop and use three computer

simulation/video tape programs to gather information from individual students.

The results of this research will be disseminated through publications, through presentation at professional meetings and through workshop materials for college and high school teachers to be developed by the principal investigator.

David A. Goslin
NATIONAL ACADEMY OF SCIENCES
National Research Council
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Washington, DC 20418

MDR 8470489
FY 85 $131,620
(12 months)

"Involving Scientists, Mathematicians and Engineers in Research in Education"

The National Academy of Sciences/National Research Council has established a major new Committee on Research on Mathematics, Science, and Technology Education, chaired by James G. March, Stanford University, and composed of a diverse group of distinguished behavioral and social scientists, educational researchers, and representatives of engineering and the physical, mathematical, and biological sciences. Over the next several years, the committee will explore, in-depth, a range of issues and topics generated by the committee and its sponsors leading to the development of recommendations for research that will contribute to the improvement of precollege education in mathematics, science and technology education. Currently, the committee has support from the National Institute of Education, the Carnegie Corporation and the W. T. Grant Foundation.

This project will develop strategic policies and Academy activities intended to increase the involvement of scientists, mathematicians and engineers in research on the learning and teaching of their subject matter. In the project, the committee will address the issue of encouraging the needed collaborative research and the recruitment of outstanding talent in two ways.

First, the committee will identify potentially useful strategies for generating interdisciplinary research and the conditions under which these strategies might be successful for research on mathematics and science education. The outcome of this part of the Committee's work is intended to be a strategic plan for NSF and other agencies that support scientific and educational research, a plan that could guide the development of programs fostering collaborative work of high quality and establishing interdisciplinary research in science and mathematics education as an important field of inquiry.

Second, the committee will explore ways in which the Academy itself can assist in strengthening the field. In particular, the committee plans to investigate the possibility of holding a National Academy of Sciences colloquium on interdisciplinary research in science and mathematics education. The major objectives of the colloquium would be to integrate the results that collaborative research has yielded already and, more importantly, to define the field and stimulate a greatly increased level of activity. The committee will develop a detailed plan for the colloquium, including an agenda, a list of key speakers and possible topics, and a general invitation list as the outcome of this second part.

Susan Gross
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(RAND CORPORATION)
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MDR 8470384
FY 85 $125,455
(18 months)

"An Investigation of the Factors Related to Mathematics Course Enrollment for Senior High School Students"

The Montgomery County Public School System will analyze the processes which lead to differential enrollment in mathematics courses at the high school level, focusing on factors affecting women and minority students.

The study has the following major objectives: 1) to create a longitudinal mathematics course enrollment model for Grades K-12 and to identify within the model the key decision points leading to participation in higher-level mathematics courses; 2) to identify and describe school and societal factors at these decision points contributing directly to mathematics course enrollment choices; 3) to develop models describing the factors affecting the high-level mathematics course enrollment of women and minorities with the goal of defining the ways in which the processes governing the choices of these traditionally underrepresented groups are the same or different; and 4)to provide, where possible, the policy implications of the research and suggest alternatives or solutions which schools might wish to explore in increasing the enrollment of women and minorities in mathematics.

The study will employ a combination of data collection and analysis techniques, using both record data available from central files and specially developed interview instruments. Overlapping cross-sectional cohorts of students will be used to build a longitudinal picture of processes operating in grades K-12.

Douglas A. Grouws
MDR 8470265
FY 85 $178,746
(36 months)

Co-P.I.:

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"Naturalistic and Experimental Study of Mathematical Problem Solving in Secondary Schools"

This research focuses on the identification of teaching behavior that facilitates the acquisition of problem-solving ability by high school students. In years one and two, teachers who are particularly adept and stable in generating large problem-solving gains from one year to the next are identified by administering beginning and end of year problem-solving tests to their students. Teachers are regularly observed and interviewed throughout the school year to ascertain their teaching behavior, beliefs, attitudes, and conceptualizations. Especially effective teachers are intensively studied in year two.

During year three, the investigators will experimentally test the question: Do teachers who modify their instructional behavior to more closely conform to the teaching profile of the effective problem-solving teachers generate larger pupil problem-solving gains than do control teachers who continue to teach in their usual ways?

Previous research has tended to focus on how the learner acquires problem-solving ability and this is then integrated into classroom problem-solving programs. The current research studies the teacher directly and thus begins work on an important but previously neglected factor in the acquisition of student problem-solving ability. The research will contribute to our understanding of teacher effectiveness and to the larger goal of improving student learning in the key area of mathematics problem solving.

Frank K. Lester
MDR 8550346
Department of Curriculum and Instruction
FY 85 $69,455
(12 months)
309 School of Education
FY 87 $62,007
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"Role of Metacognition in Mathematical Problem Solving"

Among recent research on memory and cognitive development, there is a growing interest in phenomena referred to as metacognition. This basically consists of two components: cognitive self-awareness and behavior regulation. Such research has largely been the domain of developmental psychologists, reading specialists and special education researchers. Only recently have members of the mathematics education community become interested in the role of metacognition in mathematical performance. This study will investigate the metacognitive behavior of sixth grade students working on arithmetic computation and verbal problems.

The metacognitive behaviors will be examined through the use of paper-and-pencil tests, individual interviews and paired interviews. The investigation will also include an instructional treatment component designed to engage students in metacognitive activities during problem solving. The proposed study will:

1. design, collect and pilot-test suitable mathematics problems;
2. conduct clinical interviews, observe student problem solving;
3. develop and present instructional treatments; and
4. analyze students' performance and report results.

The results of this investigation should give insights on how to incorporate a metacognitive dimension into problem solving instruction.

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MDR 8410567
FY 85 $93,022
(36 months)

"Investigation of Student Strategies in Physics"

This project is a detailed investigation of the strategies employed by students to make predictions about the behavior of physical systems. The students will work paper-and-pencil task sets on physical systems from the following topic areas: 1) Action of gravity on objects, 2) Conservation of energy, 3) Projectile motion, 4) Kinematics and dynamics of rotational motion, and 5) Standing and flowing liquids. The task sets are rule-assessment materials (Siegler, 1976) which allow for the identification of the strategy, also called a rule, that a subject uses to solve the problems.

The project has three phases. The first will look for patterns of strategies used in each of the topic areas among undergraduate students not enrolled in any physics courses. The second phase will look for changes in patterns of usage across age. Subjects will be students from grades 7-12.

The third phase will be an investigation of the interaction between initial strategy and feedback about the actual behavior of the system. The feedback will be in the form of direct observation of arrangements from the pretest.

This will allow the subjects to check the accuracy to their predictions. Subjects will then take immediate and delayed - two or three months - posttests to determine immediate and long-term alteration in their strategies.

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MDR 8550350
FY 85 $83,173
(12 months)
FY 86 $160,437
FY 87 $ 82,357

"Mathematical Problem Solving: Affective Influences on Cognitive Processes"

Research on mathematical problem solving has made substantial progress in characterizing the cognitive processes that are important to successful performance. However, the influence of affective factors on these cognitive processes has yet to be studied in detail. The purpose of this project is to investigate the affective factors that help or hinder performance in mathematical problem solving.

The major activities of the project include the development of a theoretical framework for affective factors in problem solving, the gathering of empirical data in both laboratory and classroom settings to provide a preliminary test of the theory, and dissemination of the results to both researchers and practitioners.

The theoretical development will be guided by an interdisciplinary team including cognitive scientists and mathematicians, as well as mathematics education researchers and practitioners. This group will meet first to discuss related theory (especially that of Mandler) and to outline a series of empirical studies. A year later they will meet again to discuss the results of the studies, to tailor the theoretical ideas to meet the needs of mathematical problem solving, and to disseminate the results to both researchers and practitioners.

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MDR 8550320
FY 85 $84,968
(12 months)
FY 86 $90,927
FY 87 $97,390

"A Longitudinal Study of the Acquisition of Science Concepts in Elementary School"

The proposed research has these objectives: 1) to track students' acquisition of scientific concepts from their home and school environments from kindergarten through fifth grade, 2) to assess students' knowledge and reasoning in several scientific subject areas, and 3) to analyze data from the home environment, textbooks, and classroom instruction in order to produce a causal model of how students acquire science concepts.

This study will run in tandem with a study funded by the Center for the Study of Reading on how students learn to comprehend science text. The work will be conducted with approximately 1,000 students form four school districts. Funding from the National Science Foundation will be used to: revise and administer parent questionnaires and student diary procedures; analyze science textbooks; observe science instruction; code student work; develop, pilot and administer new science measures; and analyze the data.

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MDR 8470273
FY 85 $182,857
(36 months)

"Developing Thought Processes in Elementary Algebra"

Even when the curriculum seems excellent and teachers are skilled, an alarming number of students still have problems in learning and retaining the content of elementary algebra. Why? The hunch to be tested in this research is that for many students, the learning of algebra requires problem-solving processes that are generally not developed in their prior learning of mathematics. These include the ability to perceive what is mathematically important in a given algebraic task, to reverse the flow of thinking used in solving the task, and to flexibly consider alternative ways of solving the task.

The hypothesis will be tested through clinical methodologies which bring together researchers, evaluators, and classroom teachers to develop a model for instruction. Teaching experiments will be conducted with three elementary algebra classes. Clinical interviews will examine the development of the thought processes of above-average, average, and below-average students as they "think aloud" while solving interview problems, sample homework problems, and problems from the day's lessons. Videotapes of these interviews will be analyzed daily by the researchers and teachers to guide the flow of instruction, and results from previous research will be used to provide normative data for evaluating the development of students' thought processes.

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MDR 8550332
FY 85 $578,109
(20 months)
FY 87 $613,995

"Principled Teaching of Scientific and Mathematical Concepts"

This research aims to develop scientific and mathematical concepts through collaboration of experts in physics, mathematics, and cognitive science. The approach is based on an analysis of the underlying knowledge components and thought processes required to apply scientific or mathematical concepts — and a comparative analysis of the thought patterns of novice students.

The investigators aim to teach separately, and then to integrate, each of the identified knowledge components (e.g., explicit interpretation procedures, intuitive knowledge, symbolic aids, error-prevention measures, meta-cognitive knowledge).

Observations of individual students under well-controlled conditions, which include employing detailed computer implemented teaching programs, will be used to study and refine hypotheses about the importance of the knowledge components and teaching sequence. The work should lead to effective methods for teaching scientific and mathematical concepts.

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MDR 8550470
FY 85 $31,395
(12 months)

"A Study of Uncertainties in the Meta-Analysis of Research on the Effectiveness of New Science Curricula"

In 1981, a meta-analysis of research in science education was completed by a team of researchers under NSF Grant SED 80-12310. Individual teams synthesized the extant research using procedures developed by Glass (1976). One of these syntheses showed that the post-Sputnik or "new" science programs, on the whole, produced very positive gains in student performance (Shymansky, Kyle, and Alport, JRST 1983).

Statisticians, however, have questioned the integrity of such results because standard procedures fail to take into account the error associated with the sample estimation of the effect size. It is argued that when a set of different effect sizes are pooled across studies, the means most properly should be computed using weighting factors associated with the precision of the effect size values (Hedges, 1982).

The current research project will repeat the research analysis using these procedures as proposed by Hedges. The results should provide more reliable information on the actual effectiveness of the post-Sputnik science curricula and help to establish clearer guidelines regarding the application of meta-analysis to such questions.

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MDR 8410316
FY 85 $113,791
(12 months)
FY 86 $ 55,510
FY 87 $ 61,500

"Teaching Students to Use Mathematics: Eliminating Errors in Mapping from Natural Representational Systems to the Abstract Symbol Systems of Mathematics"

The overall goal of this research project is to understand why students have difficulty solving algebraic word problems and to investigate instructional materials that are effective in remedying these difficulties.

In previous research, the principal investigators have: 1) identified several component skills related to performance on a particular subclass of algebraic word problems that require students to translate problem content into algebraic form, and 2) have developed techniques to help students develop these component skills. In the current study, the principal investigators will conduct teaching experiments to explore whether the specific component skills are necessary and sufficient to overcome the problem-solving difficulties.

Three computerized modules for teaching underlying skills will be developed (one in algebraic transformations, a second in nonalgebraic transformations, and a third in algebraic symbolization). Their effectiveness will be tested with high school students of varying mathematical abilities. By analyzing data on individual measures and on the experimental procedure, the investigators will examine how individual differences in mathematical ability and learning experiences interact in their influence on problem solving. The results of these analyses are particularly relevant to the practical issue of how best to provide the experiences necessary for otherwise competent students to develop problem-solving skills essential for succeeding in mathematics courses.

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MDR 8550169
FY 85 $60,980
(12 months)
FY 86 $47,916

"Concept-Driven Strategies for Solving Story Problems in Mathematics"

Recent work suggests that many children attempt to solve routine mathematical story problems with strategies that are not based on an understanding of the arithmetic operations. Although these immature strategies may lead to success on many one-step story problems with whole numbers, use of such strategies with multi-step problems or story problems involving fractions or decimals is unlikely to give correct solutions.

The proposed work will gather more evidence on the strategies children use in solving story problems and their understanding of the arithmetic operations. In addition, instructional materials which foster a more mature, meaning-driven strategy will be designed and field tested. Methodologies will include group testing, individual interviews, examination of textbooks, teaching experiments, and testing of materials in approximately twenty sixth-grade classrooms.

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MDR 8550463
FY 85 $152,912
(24 months)

"Child Generated Multiplying and Dividing Algorithms: A Teaching Experiment"

The primary purpose of this project is to map child generated multiplying and dividing algorithms as they are elaborated by children. This first part of the work has two aspects. First, the principal investigators will specify the multiplying and dividing algorithms that are indicated by the mathematical behavior of children. Second, they will specify the step-bystep construction of these algorithms.

A second purpose of the project is to specify the pedagogical

implications of these child generated algorithms for school mathematics instruction. Toward this end, these investigators will elaborate their teaching strategies and will develop written materials for teachers. The primary methodological tool is the constructivist teaching experiment. With six eight-year old children as subjects, the investigators will conduct a two-year teaching experiment, each consisting of three series of sequential teaching episodes — one series in the fall, one in the winter, and one in the spring. Each series will be of four weeks duration and will consist of a sequence of 32 teaching episodes, eight per child.

Video tapes of each episode constitute the primary data base that will be intensively analyzed in the specification of multiplying and dividing algorithms and their progressive construction by the children. The investigators contend that specification of these algorithms and of their development can provide powerful guidelines for the teacher who seeks more effective teaching methods.

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MDR 8470277
FY 85 $130,901
(18 months)

"Problem Solving in High School Genetics: Microcomputers and Realistic Problems"

This research will explore the effects of a combination of microcomputers and information processing psychology on issues related to teaching, learning and problem solving by high school students in the subject area of transmission genetics. The problem solving behavior of high school students and teachers will be studied using the strategic computer simulation, BUGCROSS.

Data will be gathered on these two groups as they "think aloud" while solving problems generated by BUGCROSS. The study is part of a larger, on-going research program on learning and problem solving in genetics. The overall aims of this program are: 1) understanding of the primarily algorithmic procedures and conceptual knowledge that high school students use to solve typical textbook problems in genetics (This aspect has been completed with support provided under NSF grant SED 80-22912.); 2) development of classroom materials and procedures to promote meaningful learning and problem solving; 3) development of a model of desired performance in transmission genetics through the study of expert performance on similar problems as well as an analysis of the structure of knowledge (declarative and procedural) in transmission genetics; 4) development of a model of high school student (novice) performance on problems generated by BUGCROSS; and 5) the development of a model of instruction in transmission genetics.

This research is significant to theoretical issues in problem solving as well as to practice in genetics education. It will help to provide a detailed understanding of how high school students and their teachers solve the realistic problems presented by BUGCROSS, and should also apply to the teaching of genetics in introductory college courses, since the content and the background of both groups of students are similar.

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MDR 8470215
FY 85 $360,280
(24 months)
FY 87 $142,410

"Increasing the Effectiveness of Biology and Chemistry Instruction Through Research Applications"

Previous work by these investigators has indicated that significant advances in teaching and learning can be attained by applying the principles of wait-time feedback and subject-specific, supportive intervention.

The current project will test the significance of two strategies in achieving: 1)increased student involvement; 2) increased interaction and improved student attitudes; 3) increased student achievement in biology and chemistry; 4) increased elective enrollments in science; and 5) enhanced teacher job satisfaction. The project will also disseminate practices that enhance instruction and will instruct master teachers and team leaders in more effective techniques.

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MDR 8550138
FY 85 $84,834
(12 months)

"An Analysis of Classroom Processes Data From The Second International Mathematics Study"

A unique and highly significant component of the Second International Mathematics Study consists of the data on classroom processes — how much mathematics is taught and the ways in which the teacher deals with that subject matter. To date, only limited analysis has been carried out on the classroom processes data that were gathered from national samples of eighth and twelfth grade classrooms. This information is included in the U. S. Summary Report, presented at the National Conference on Teaching and Learning Mathematics, September 1984.

The current project, will analyze these data to explore both how teachers handle the subject matter of mathematics and what relations exist between these processes and student outcomes (achievement and attitudes). Two intensive data analysis and reporting sessions are planned for the summer and fall of 1985, culminating in a national conference on the findings to be held in late November 1985. The proceedings of the conference, which will include data presentations, findings of analyses, invited reaction papers, as well as discussions of implications of the findings for policy and practice, will form the basis of a monograph to be published in the spring of 1986.

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MDR 8470424
FY 85 $159,865
(12 months)
FY 86 $172,214
FY 87 $191,396

"Survey of Applied Soviet Research in School Mathematics Education"

Soviet efforts to study the psychological aspects of mathematics learning have resulted in a large body of outstanding research. Focuses of Soviet research include principles of conceptualization, problem solving, logical reasoning, programmed instruction, spatial perception, and mathematical abilities. The results of this extensive research are being employed to advance the quality of mathematics instruction in the Soviet Union.

The project will make some of the best of this highly original and previously inaccessible research available to American educators by publishing adaptations of 40 selected Soviet research monographs, 25 of which have already been translated under NSF auspices at the University of Chicago. American experts are to engaged as volume editors. The project will provide resources that will enrich U. S. research and also find immediate use in instructional development and practice through the University of Chicago School Mathematics Project operating in the Chicago public schools. Dissemination of the project's work will occur through meetings of such professional societies as the National Council of Teachers of Mathematics and the American Educational Research Association and through written articles interpreting implications for research and for classroom instruction in mathematics in the U.S.

FY 1986 Awards

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MDR 8651603
FY 86 $130,048
(12 mos)
$65,048 (RTL)
$65,000 (SPA)

"Second International Mathematics Study: Student Growth and Classroom Processes in Lower Secondary School"

A report on the international results from the longitudinal portion of the IEA Second International Mathematics Study (SIMS) will be prepared by an international team of mathematics educators and other educational researchers and will appear as Volume III in a series to be published by Pergamon Press, London. SIMS is a cross-national study of the content of the curriculum, what is taught and what is learned in school mathematics at two age/grade levels, Grades 8 (Population A) and 12 (Population B), in the United States and several other countries.

This investigation will examine mathematics learning ("growth") during the course of a year of instruction and its relationship to specific teaching practices and processes in lower secondary school mathematics classrooms (Population A) in eight participating countries [Belgium (Flemish), Canada (British Columbia and Ontario), France, Japan, New Zealand, Thailand, and the United States]. This investigation of student performance and teaching practices, within a broader sociocultural perspective than is possible using only within-country data, represents a unique opportunity to inform national policies and practices at a time of concern about the quality of American mathematics and science education.

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MDR 8651591
FY 86 $28,954
(12 mos)

"The Psychology of Physics Problem Solving: Theory and Practice"

The past nine years have yielded a large research corpus on the psychology of physical-science problem solving. Several research approaches have developed analyses of problem solving in physical science, emphasizing such aspects as qualitative conceptions and search strategies. It is now appropriate to evaluate what we have learned and what remains to be done in developing a coherent theoretical approach that supports physical science education.

Funds are being provided for a four-part working conference that will enable major researchers in the area of physics problem solving and education to address this problem. The first part will attempt to confront and coordinate different research approaches to develop a core model of problem solving by novices in physics. The second part will develop the educational implications of the core model. The third part will critique the core model by considering what science educators need from a theory of problem solving to advance the effectiveness of physics instruction. In light of the critique, the fourth part will discuss methodological and conceptual approaches that would better coordinate psychological theory and educational practice.

The conference is scheduled to meet from July 21-23, 1986. Working papers prepared beforehand will be used to focus and initiate discussion. The results of the discussions will be disseminated through an American Educational Research Association symposium and three papers for appropriate research and education journals that summarize the current understanding of novice physical-science problem solving, the limitations of that understanding for educational purposes, and directions for future research.

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MDR 8550343
FY 86 $35,311
(18 mos)

"The Effects of Homework on Science and Mathematics Achievement and Attitudes: An Integrative Research Review"

The practice of requiring students to carry out academic tasks during nonschool hours is as old as formal schooling. Assessments of the value of homework, however, have fluctuated over time with strong positive opinions prevailing at the turn of this century and the early 1960's and negative opinions holding sway in the 1930's and 1970's. Recently, in response to calls for higher standards of excellence in American education, schools have begun to place increased emphasis on homework as a means for improving student performance.

Opinions of homework and its utility have never been greatly influenced by empirical data on the subject. This is due partly to a general lack of public information on what research says about homework and partly to the seemingly contradictory findings of studies.

The purpose of this project is to locate, describe, summarize, and integrate the empirical research concerning the effects of

homework on numerous student outcome variables. Outcomes will include all the dependent measures employed in previous research, with special attention paid to academic achievement, attitudes toward school, and study habits. The review will go beyond previous reviews by (1) including the most recent research; (2) paying the greatest attention to schooling, homework, and research method characteristics that might mediate the effects of homework; (3) focusing on homework effects on different subject matters, with *special attention paid to science and mathematics*; and (4) employing quantitative synthesis techniques to estimate the impact of homework and uncover any subtle homework effects.

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MDR 8550896
FY 86 $125,590
(12 mos)

"An Exploratory Study of 3-2-1 Contact"

This research project will explore a number of factors concerning the children's television series "3-2-1 Contact" including: (1) awareness of the series on the part of children, parents, and teachers; (2) perceptions of appeal and comprehensibility of the program format among both viewers and non-viewers; (3) the demographics and viewing habits of viewers and teacher users; (4) reasons for particular modes of viewing and use; and (5) impacts that result from viewing. A major goal of this exploratory study is to identify factors that require more detailed, controlled research before their influence can be fully understood and that offer promise of productive research because their influence is clearly significant.

The study will focus on 100 children in the 8-12 year age range (the target audience), 100 viewers in the 4-7 year age, 100 parents of viewers, and 150 teachers of grades 3-6. Two-hour group sessions will provide study subjects with opportunities to respond to questions on series awareness, modes of viewing and using the series, and series impact. Subjects will complete written questionnaires, view selected program segments from the series, and then participate in oral interviews.

The expected outcomes of the study are: (1) a description of the viewing audience; (2) an understanding of patterns of series viewing at home and use in the schools; (3) the role of parents and teachers in stimulating children to view the series; (4) a picture of audience response to program formats and performers; and (5) a measure of program comprehensibility among different types of viewers. The final outcome will be a comprehensive research model for additional study of "3-2-1 Contact" as a vehicle for science education.

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MDR 8652146
FY 86 $59,280
(12 mos)

"Investigating Children's Concepts of Light and Vision in a Science Museum Setting"

This exploratory project will study the intuitive notions of light and vision that are held by children ages 10-14. A novel feature of this work is that it takes place in a science museum and uses interactive exhibits as the tasks that mediate the interviews with the children. The project is expected to yield results that are novel and that complement those obtained from work done in the school setting. The specific aims are: (1) to expand the existent empirical data on the explanations given by children by exploring the subject matter area of optics-shadow-formation, images and color; (2) to determine the nature of tasks, activities and experiences that enhance conceptual understanding and aid the child's development of scientifically valid concepts; (3) to determine what overall organizing principles are most useful for the researcher and for the teacher.

The project will begin to explore the practical applications of this research for (1) exhibit design and, by extension, classroom activities; (2) the use of hands-on museums for exhibit-based learning and teaching; (3) strategies for enhancing concept acquisition that can be used for curriculum development and teacher education in both formal and informal settings.

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MDR 8550921
FY 86 $52,744
(9 mos)

"Planning Conference: Strengthening the Research Base for Science Education"

Science education requires a solid research base if long-term gains in educational quality are to be achieved and consolidated. This research base must take account of the content and structure of subject matter disciplines, the contexts in which science teaching occurs, and the principles of teaching, learning, and reasoning in scientific domains that are emerging in research.

This project will convene a planning conference on research for science education that will bring together forty leading professionals who are experts in (1) subject matter disciplines of science, mathematics and computer science; (2) the study of classroom teaching and curriculum development; and (3) the

study of cognitive processes of learning, reasoning and problem solving. Conference participants will assess the current state of knowledge, examine the prospects for advances based on currently available resources, and identify activities likely to significantly increase this knowledge and lead to changes in educational practices in science education.

Project participants will develop plans for further collaboration and follow-up activities. In addition, the participants will draw up a specific set of recommendations and priorities for mathematics, science and technological education, including suggestions concerning the relative merits of various research methodologies.

Conference proceedings will be published and distributed to 3,000 members of professional educational research societies, universities, research centers, funding agencies and other interested parties. Results of the conference will be discussed in organized symposia and will be presented at appropriate professional meetings in 1986.

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MDR 8550619
FY 86 $157,948
(12 mos)
FY 87 $173,349
FY 88 $ 46,577

"Small-Group Instruction in Mathematics: Naturalistic Research in Teaching and Learning"

This systematic research project of classroom teaching and learning of mathematics in grades 3 through 6 is intended to : (1) describe teachers' beliefs about small-group mathematics instruction with a particular interest in specifying mathematical content that is especially appropriate for small-group instruction; (2) identify instructional strategies teachers use during small-group instruction; (3) replicate those instructional strategies in different educational contexts; (4) examine small-group instruction in the areas of problem solving, estimation, and measurement (making videotapes of these lessons as well as coding classroom behavior); (5) examine the correlation between different small-group instructional *strategies* and students' mathematics performance; (6) with the assistance of the National Advisory Board, develop at least two innovative treatments for improving the effectiveness of small-group mathematics instruction; and (7) disseminate the results of the project in a monograph discussing research findings and concepts and in a videotape(s) that will illustrate effective practices.

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SPA 8652096
FY 86 $228,313
(18 mos)
$226,000 (RTL)
$ 2,313 (SPA)

"Persistence in Science of High Ability Minority Students"

A study will be conducted by the Educational Testing Service (ETS) of the educational progress of black, Mexican American, Puerto Rican, and American Indian students of high ability (scoring 550 or above on SAT math and scoring in the upper quartile on achievement measurement in HS & B) who intend to enroll in college and to major in mathematics, science, or engineering. Three cohorts will be studied: (1) the students in high school and beyond who were high school seniors in 1982 and subsequently were followed up at two-year intervals; (2) SAT-takers who were high school seniors in 1984; and (3) SAT-takers who were high school seniors in 1986. All the qualifying SAT-takers will be surveyed by mail and a randomly selected subsample of at least 100 in each cohort will be interviewed by telephone. The combination of cross-sectional and longitudinal data will permit an analysis of variables related to the progress of the persisters and non-persisters in each cohort at various time points. Whether these characteristics are changing will be of importance.

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MDR 8651552
FY 86 $178,226
(36 mos)

"Instruction and Cognitive Change in Mathematics: Learning Decimal Numbers"

The project examines changes in cognitive processes resulting from instructional interventions and applies this information in developing a prototype instructional program. The cognitive processes of interest are those involved in constructing meaning for decimal number symbols and using the meaning to solve decimal number tasks. Previous work suggests that for many students, the lack of meaning for written symbols is the source of low performance across a range of mathematical tasks. Classroom instruction designed to promote cognitive processes that create meanings for symbols is implemented and evaluated in the context of decimal fractions.

Students in grades 4 and 5 will be instructed in whole classroom settings. Written tests and a series of individual interviews will

provide information on changes in key cognitive processes and on how such changes are induced by specific instructional events. The information on cognitive change and instructional effectiveness, gathered through a sequence of instructional studies, will be translated into a prototype instructional program for developing meaning for written symbols in mathematics.

Moving from research to practice, from descriptions of students' performance to prescriptions of instructional programs, is a major objective of this program of research. In addition to providing new knowledge and product outcomes, the project provides a model, based on chain of inquiry notions, for translating research into practice.

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MDR 8554464
FY 86 $196,359
(24 mos)
$146,359 (RTL)
$ 50,000 (AAT)
FY 88 $ 106,183

"LOGO Debugging Skills: Analysis, Instruction and Assessment"

This research addresses the question of how an important computer programming skill — debugging — is acquired by elementary and middle-school children, and what the cognitive consequences are of acquiring that skill. One preliminary goal of the proposed research is the development of a well-specified and empirically-supported account of what a child has to know in order to debug a computer program. The proposed work extends preliminary studies of the debugging skills acquired during the course of a normal LOGO curriculum, and it provides for further assessment and elaboration of a computer-simulation model of the precise components of debugging skill.

The work will have several interacting components: (1) Empirical evaluation of the model based on a study of experienced programmers' debugging processes; (2) Further development of precise assessment procedures for determining what component skills a student has acquired; (3) Extending the model to a wider range of programming contexts; (4) Using the model to guide specific instructional procedures in teaching debugging skills; (5) Extending and applying a complete one-semester LOGO curriculum with an emphasis on instruction in and assessment of debugging skills; (6) Determining the extent to which debugging skills, once taught, can transfer to near and far tasks; (7) Construction of a model-based prototype debugging aid on a powerful graphics workstation.

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MDR 8550085
FY 86 $296,783
(15 mos)
$146,783 (RTL)
$150,000 (SPA)

"A Longitudinal Study of the Development of Adolescent and Young Adult Attitudes Toward and Knowledge About Science and Technology"

The middle-school and high-school years are a period of change and crystalization in terms of life goals, disciplinary and course preferences, and social and political attitudes. The literature provides a number of cross-sectional descriptions and models concerning cognitive and attitudinal development during adolescence and young adulthood, but there are no longitudinal data available to study these processes.

The proposed longitudinal study will examine the (1) development of interest in science and mathematics, (2) the growth of scientific literacy, (3) the development of attentiveness to science and technology issues, and (4) the attraction to careers in science and engineering among two national cohorts of adolescents and young adults. One cohort will begin with a national sample of 3,000 7th graders and follow them through the 10th grade. The second cohort will begin with a national sample of 3,000 10th graders and follow them for the next four years through the first full year after high school. Data will be collected from students, teachers, counselors, principals, and parents.

A purposive sample of two or three school districts with exemplary elementary school science and mathematics education programs will be selected and comparable data will be collected in these districts.

The analysis will consist of a series of expanding multivariate developmental models that will seek to understand cognitive and attitudinal growth and change in the context of family, school, and peer influences. Each wave of data collection will provide an opportunity to examine cognitive and attitudinal change measures in an increasingly rich context of previous measures. Periodic reports will be issued with each cycle of data collection and the data will be made available to other scholars on a timely basis.

The first phase of the project, being funded at this time, provides approximately 15 months for instrument development and pilot testing, for sample selection, for monitor selection and training, and for working with the research advisory committee.

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MDR 8650008
FY 86 $306,548
(36 mos)

Co-PI:

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"Metacognition, Teachers and Mathematical Problem Solving"

Some mathematics educators have taken the position that metacognition -knowledge and beliefs about cognitive activity as well as awareness and control of that knowledge — is critical to mathematical performance and that research in mathematical problem solving would benefit from exploration of this phenomenon. This project is designed (1) to investigate the relationship between inservice middle school teachers' metacognitive activity and mathematical knowledge and their problem-solving ability, and (2) to improve teachers' problem-solving ability through a problem-solving institute focusing on metacognitive knowledge and experience in mathematical problem solving.

Fifteen middle school teachers enrolled in an institute on problem solving and thinking will be the subjects in the study. Subjects will be videotaped solving unfamiliar problems before small groups of their own students and will be tested for problem-solving performance before and after the institute. Techniques for recording and analyzing metacognitive activity are grounded in the work of Schoenfeld (1983), and problem-solving performance will be evaluated using a process/product scale developed by Lucas et al. (1979) and Schultz (1985).

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MDR 8550211
FY 86 $61,096
(18 mos)

"A Conference on the Van Hiele Model of Geometric Thought"

In 1957 in the Netherlands, Pierre Marie Van Hiele and his wife Dina Van Hiele-Geldof postulated a model of the development of geometric thought. The model, which posits the existence of discrete levels of geometric thinking and phases of instruction that help students progress through the levels, explains why many students have difficulty learning geometry. Since 1979 three major research studies have investigated the validity of the Van Hiele model and its applicability to American Schools.

The project will convene 30 people (the principal investigators and senior personnel from previous Van Hiele-based research, scholars from mathematics education, psychology and computer science, local supervisors, and teacher trainers) for a two and one half day conference at Syracuse University. The objectives of the conference are (1) to analyze, synthesize, and evaluate recent research on the Van Hiele model; (2) to examine alternative models of geometric thinking; (3) to plan ways to utilize current research results in developing materials for students and teachers of geometry; and (4) to outline directions for future research.

Conference proceedings will be disseminated via a book of scholarly papers edited by the conference organizer, via journal articles and other professional publications, and via workshops and lectures by conference participants at professional meetings.

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MDR 8550614
FY 86 $218,711
(14 mos)
FY 87 $164,760

"The National Council of Teachers of Mathematics Research Agenda Project"

Research efforts in some areas of mathematics education have developed to a point where consensus is needed to establish a conceptual framework to guide future inquiry. The Research Advisory Committee of the National Council of Teachers of Mathematics has identified four such areas: teaching and learning of middle school number concepts, effective mathematics teaching, the teaching and learning of algebra, and the teaching and evaluation of problem solving.

The proposed project will establish working groups in these areas. Each of the four groups will meet for a four day conference to consider the significant issues in the area. Each conference will feature presentations by authors of invited papers, small group discussion sessions, and plenary sessions. The purposes of these conferences are to synthesize the current knowledge base in each area, identify significant directions for future research, and develop collegial research groups. Four monographs — one from each working group conference — will disseminate invited papers, conference proceedings, and the research agendas established by the conference participants. A fifth monograph will contain a variety of viewpoints on the proceedings and resulting agendas through retrospective papers by members of the project advisory council.

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BNS 8605588
FY 86 $69,098
(12 mos)
$50,000 (RTL)
$19,098 (SDP)

"Mathematics Achievement: Japanese, Chinese and American Children"

American students lag behind students of many countries in their achievement in mathematics. Chinese and Japanese students, on the other hand, have obtained scores yielding some of the highest national averages in a number of cross-national comparisons involving many countries. This has been found to be true for first-graders and fifth-graders in previous research by these investigators and for junior- and senior-high students in studies by other investigators.

Stevenson and his collegues are now exploring the question of why young American children perform so poorly. In their recent research, they have assessed mathematics achievement of first- and fifth-graders in Sendai, Japan; Taipei, Taiwan; Chicago, Illinois; and Beijing, China through a group test of calculation and 12 individually administered schools in each city were tested, except for Chicago, where a representative sample of 20 schools was selected. Individual tests were administered to 3 boys and 3 girls, randomly selected from each classroom. Four hours of observation of mathematics classes in each classroom were conducted. Two observers were present each hour, one writing a running description of the content of the lesson, and the other following a coding scheme developed for a time-sampling procedure. Mothers of the subsample of children from each classroom were interviewed concerning daily activities at home, and the teachers in each classroom were interviewed concerning their beliefs and practices concerning mathematics instruction. A questionnaire was given to the fathers of the children in the subsample and a brief interview was conducted with the principal of each school.

This grant provides funds for data analysis. Analyses of the data will be directed at the cross-national comparison of mathematics abilities and at the detection of significant correlates of mathematics achievement.